Chemical

Chemical Annual Report

Fiscal Year 2003

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry
through imporvements in energy and environmental performance

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Industrial Technologies Program — Boosting the Productivity and Competitiveness of U.S. Industry

Industry consumes 33 percent of all energy used in the United States. By developing and adopting more energy efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. Through an innovative strategy known as Industries of the Future (IOF), EERE's Industrial Technologies Program (ITP) seeks to improve the energy intensity of the U.S. industrial sector through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. The primary long-term strategy is to invest in high-risk, high-return R&D. Investments are focused on technologies and practices that provide clear public benefit but for which market barriers prevent adequate private-sector investment.

The IOF strategy maximizes the energy and environmental benefits of ITP's process-specific technology investments by forming collaborative partnerships with energy-intensive industries. These collaborations aim to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. The IOF public-private partnerships also facilitate voluntary efforts, such as the President's Climate VISION initiative, to encourage industry and government to reduce greenhouse gas emissions. ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 75 percent of industrial energy consumption:

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum Refining
- Steel

ITP also conducts R&D projects on enabling technologies that are common to many industrial processes such as industrial energy systems, combustion, materials, and sensors and process control systems. In addition, ITP funds technical assistance activities to stimulate near-term adoption of best energy-saving technologies and practices within industry. These activities include plant assessments, tool development and training, information dissemination, and showcase demonstrations.

New technologies that use energy efficiently also lower emissions and improve productivity. By leveraging technical and financial resources of industry and government, the IOF partnerships have generated significant energy and environmental improvements that benefit the nation and America's businesses. Energy-intensive industries face enormous competitive pressures that make it difficult to make the necessary R&D investments in technology to ensure future efficiency gains. Without a sustained commitment by the private and public sectors to invest in new technology R&D and deployment, the ability to close the gap between U.S. energy supply and demand will be severely compromised.

CONTENTS

EXHIBITS

EXECUTIVE SUMMARY

Today's chemical industry faces significant challenges in maintaining its leadership position in global markets. Competition from developing countries where energy and labor are cheaper is putting increasing pressure on U.S. producers, and is exacerbated by the increasing volatility of the energy supply. Growing societal demands for environmental stewardship and demand for shorter-term returns on investment continue to impact the availability of R&D funds, especially for basic and applied research. The skilled workforce conducting chemicals R&D has dropped by 10 percent. These challenges have led to a major change in this highly competitive industry. Companies are now willing to collaborate in strategic, pre-competitive areas to reduce costs, environmental impacts, and energy use.

The U.S. chemical industry is the second-largest consumer of energy in manufacturing, using more than 6.3 quads of energy in 2001 (the largest industrial user of energy is the petroleum refining industry). The magnitude of energy consumed by the industry makes it a prime target for energy efficiency R&D. Increasingly stringent environmental regulations associated with the combustion of fuels, and the growing volatility of energy markets are making investments in energy efficiency R&D more attractive. Record high prices for natural gas over the last 2 years and growing dependence on imported oil threaten national energy security and make a strong case for reducing energy use.

Permanent technology changes, rather than short-term fixes, are needed to revolutionize the way energy is used in chemicals manufacture. New catalysts, for example, can dramatically increase product yield (the amount of product obtained from every barrel of oil) and reduce feedstock requirements. More efficient process heating technology can reduce the use of fuels and electricity.

A Successful Partnership with Industry

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) leads the federal role in developing advanced energy-efficient and environmentally friendly industrial technologies. Chemical industry R&D is a component of the overall EERE strategy and contributes to the goals outlined in the National Energy Policy. Improving energy efficiency in chemicals manufacture could directly reduce the amount of petroleum imported into the United States, and will reduce the energy intensity of industry, two of EERE's top priorities.

> *The Chemical IOF will help the chemical industry achieve a 30 percent reduction in energy, water use, and toxic and pollutant dispersion per unit of output by 2020.*

The EERE Industrial Technologies Program implements the Chemical Industries of the Future (IOF) effort, which seeks to boost efficiency and productivity of the energy- and resource-intensive chemical industry by investing in a balanced R&D portfolio with broad applicability in chemical processing. The Chemical IOF works in partnership with the Chemical Industry Vision2020 Technology Partnership (Vision2020, see www.ChemicalVision2020.org), a group of executives from major U.S. chemical companies. This group works with government, academia, and national laboratories to promote technology development of more energy-efficient, environmentally sound chemical technology. By partnering with Vision2020 and fostering collaboration with chemical industry trade organizations, the Chemical IOF leverages public and private resources and ensures the application of research results.

Achieving Energy Savings: Program Strategy

The Chemical IOF supports a diverse portfolio of cost-shared, pre-competitive research addressing technological needs that have broad applicability throughout the chemical industry. The program strategy fosters both revolutionary technologies and incremental improvement to existing processes, thereby addressing long-term goals without neglecting short-term opportunities to improve energy efficiency.

As the Chemical IOF shifts toward supporting a smaller number of high-impact projects, research activities are organized into the following categories: reactions, separations, enabling technology (materials, process heating, computations, and sensors and controls), and technology deployment. The FY 2003 Chemical IOF

Portfolio included 41 active and 23 emerging projects. Many other projects funded by EERE are applicable to the chemical industry. More information about the Chemical IOF portfolio is available on the ITP Web site at http://www.oit.doe.gov/chemicals/portfolio.shtml.

FY 2003 Highlights

- **Catalytic Hydrogen Retrofit Reactor (Monolith Loop Reactor)** – R&D is being conducted to retrofit catalyst systems into existing stirred-tank reactor systems to increase reactor rates and avoid the use of slurry catalysts. In November 2002, the project partners announced a marketing agreement to commercialize the technology. Widespread implementation of this technology offers the potential for 0.2 trillion Btu per year savings by 2020, the year of complete market penetration. DOE cost-share was completed in 2002.

- **Membranes for Olefin Recovery** – A membrane separation process is being developed to recover olefins in gaseous olefin/paraffin waste streams for use as in-process feedstock. Commercialization of this technology could reduce energy use by 0.8 trillion Btu by 2020 and recover over 0.42 billion pounds of olefins per year. This project continued a 2001 SBIR award.

- **Pressure Swing Adsorption for Product Recovery** – An energy-efficient process employing pressure swing adsorption refrigeration (PSA) for the recovery of olefins from polyolefin plant vent gases was developed. There are already two commercial applications of the PSA technology. Widespread commercialization could yield a recovery rate of over 17 million pounds of olefins per year, as well as energy and emission reductions. Project cost-share from DOE was completed in 2002.

- **Alloys for Ethylene Production –** BP Chemicals, Exxon Chemical Company, Shell Chemical Company, Air Products & Chemicals, Oak Ridge National Laboratory, and six other industry partners are developing metallic and intermetallic materials that allow for the production of ethylene furnace tubes resistant to coking and carburization. This innovative technology has the potential to prevent carburization coke formation in tubes, allow for longer tube service life, reduce downtime, and improve reaction conditions. Potential energy savings for this project are 164.3 trillion Btu per year by 2020. Project cost-share from DOE is expected to be completed in 2003.

- **Projects Selected from the 2003 Industry of the Future Solicitation** - The FY 2003 Industry Call solicitation focused on energy-intensive processes in chemical reactions and separations. The solicitation was released in January 2003 and eight new projects were announced in August 2003. The solicitation focused on reactions including chemical synthesis, new reaction media, catalysis, reaction engineering, and process intensification. The FY 2003 solicitation reduced the cost-share requirement, increased the funding available per project, and increased the period of research.

Climate VISION

- Industrial Technologies Program (ITP) is working in partnership with U.S. chemical industry through the American Chemistry Council to implement activities in support of ACC achieving its Climate VISION commitment. A Climate VISION workplan is being developed where ACC will be collaborating with the Federal government on near-term energy efficiency activities, cross-sector projects, and R&D to develop and commercialize advanced technology (see Climate VISION Web site www.climatevision.gov/).

INDUSTRY OVERVIEW

The chemical industry is a vital part of the U.S. economy, transforming raw materials into more than 70,000 diverse products that are integral to today's quality of life. Nearly every product in use today, from transportation to plastics to paper, requires some input from the chemical industry.

Products Requiring Chemical Inputs

Plastics	Antifreeze
Paints	Printing Inks
Detergents	Textiles
Adhesives	Food Packaging
Solvents	Carpets
Pharmaceuticals	Insulation
Toys	Auto Interior Parts
Film	Paper
Plastic Bags	Cellular Phones
Medical Supplies	Microwaves
Cosmetics	Refrigerators

The chemical industry is a global enterprise worth $1.7 trillion, and the United States holds the largest market share (26 percent). In the U.S. alone there are 9,500 chemical firms with 13,000 operating facilities employing over 1 million people. The domestic chemical industry provides 12 percent of U.S. manufacturing GDP and invests $30 billion in R&D every year. Chemicals manufacture is the second-largest industrial consumer of energy, and the industry spends over $13 billion on environmental programs annually.[1,2]

Globalization and innovation are major influential forces in the chemical industry. Dynamic global demand and rapid technological change have led to accelerated restructuring, joint ventures, mergers, and acquisition activities throughout the industry. Chemical companies today are highly diversified and knowledge-based, relying on technology, science, and innovation to create value-added products and gain ground in new markets.

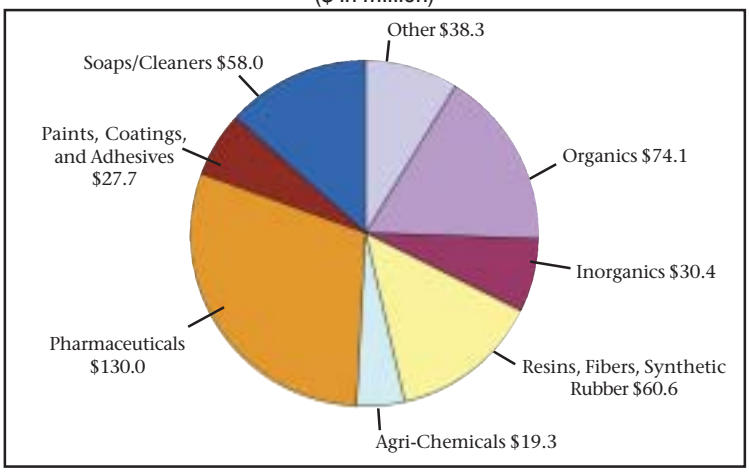
Chemical Industry Shipments and Trade

In 2001, U.S. chemical industry shipments totaled over $454 billion.[3] Exhibit 1 shows the value of shipments for the major sub-sectors. Pharmaceuticals led the industry in shipments with 30 percent of the total, followed by organics (17 percent); resins, fibers, and synthetics (14 percent); and soaps and detergents (13 percent). Over the last decade, the industry has grown at an average rate of about 4 percent per year, with some sectors experiencing flat or negative growth, while others are growing rapidly. The composition of the industry has been steadily changing, with an increasing emphasis on high technology and niche markets, such as the life sciences and specialty chemicals. While commodity chemicals continue to form the core of the industry, it is these specialty markets where the highest future growth is predicted.

The U.S. chemical industry maintains a substantial trade surplus ($1.3 billion in 2001), and is the largest exporter of chemicals in the world, with over $80 billion in products shipped to foreign trading partners in 2001. Canada, Mexico, Western Europe, and the Asia-Pacific region account for over 85 percent of U.S. export markets.[4]

Exhibit 1 Value of Industry Shipments by Sub-Sector, 2001

($ in million)



[1] *Guide to the Business of Chemistry 2002,* American Chemistry Council.
[2] *1997 Census of Manufactures,* U.S. Department of Commerce.
[3] *Guide to the Business of Chemistry 2002*, American Chemistry Council.
[4] Ibid.

Annual production of the top 100 chemicals and plastics is about 470 million tons annually. Production of organic and inorganic chemicals is estimated to be about 175 million tons and 294 million tons, respectively.[5] Plastics account for about 100 million tons per year of organic chemical production.

Energy Use

In 2001, energy consumption in the chemical industry totaled 6.174 quads, which represents 6 percent of all domestic energy use and 19 percent of total U.S. manufacturing energy use.[6,7] Energy use in the chemical industry is split almost evenly between heat and power and feedstock energy for the production of petrochemicals, plastics, and other products. During the last decade, significant improvements have been made in energy efficiency, reducing energy use per unit of output by about 44 percent since 1974.[8] Technologies such as cogeneration, advanced catalysts, and improved separations have played a major role in efficiency improvements. Today, one-third of the electricity used by the industry is produced on-site more efficiently, mostly through cogeneration, which provides both power and process heat.

Exhibit 2 shows the chemical industry's energy inputs by source. The industry is the second-largest consumer of natural gas, accounting for 26 percent of total U.S. manufacturing use, and the largest consumer of liquefied petroleum gas (LPG), at 95 percent of total manufacturing use.[9] Natural gas provides the largest share of energy for heat and power. The industry is fuel-intensive; electricity only provides about 16 percent of energy requirements. Feedstock energy is a mix of LPG, natural gas liquids (NGL), heavy petroleum liquids, and natural gas.

Energy consumption varies widely among the industry sectors. Petrochemicals and other organics account for the largest share of energy use (35 percent), followed by plastics and resins (19 percent), and fertilizers (9 percent), as shown in Exhibit 2. Energy costs on average account for about 7 percent of the value of chemical industry shipments. In 2001, the industry spent $31.4 billion in energy purchases for fuel, power, and feedstocks, a 65 percent increase over energy costs in 1999. The dramatic increases in natural gas prices in 2000 and 2001 had a substantial impact on certain sectors of the industry. About 50 percent of methanol capacity and 40 percent of ammonia capacity, both of which depend on natural gas for feedstock, were idled during that time.[10]

Within the plant boundary, about 37 percent of energy delivered to the plant is lost prior to being used in specific processes. For example, steam is used extensively in the chemical industry for fluid heating and to produce power. In the steam system, which includes boilers, steam distribution lines (pipes, valves, traps), and energy conversion systems (heat exchangers, preheaters, etc.), about 45 percent of delivered energy is lost. Process heating (both steam and fired heaters) represents the largest use of fuels in the chemical industry (77 percent), followed by motor systems (12 percent). Technologies that improve the efficiency of process heating systems have significant potential to reduce overall industry energy use.

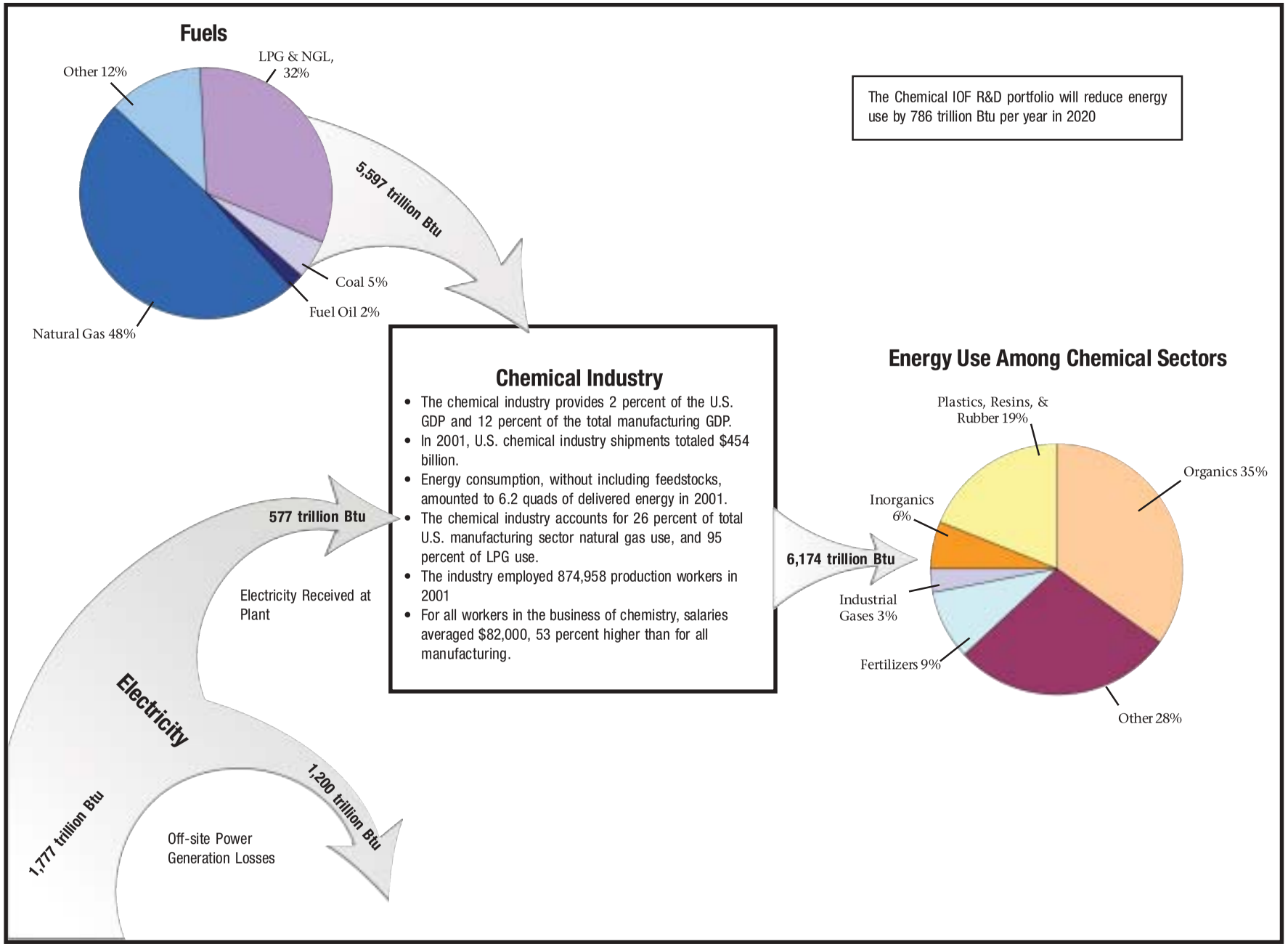
Process operations represent substantial energy sinks where new technology as well as incremental improvements can have an impact. Distillation columns, for example, the mainstay of the industry, often operate with thermal efficiencies as low as 20 percent.

The total primary energy associated with the chemical industry is 5,074 trillion Btus, which includes energy losses associated with the generation of power at off-site utilities, and the transport of fuels to the plant site. These off-site losses are considerable, amounting to about 1,345 trillion Btus. Technologies that produce electricity on-site, such as cogeneration, have the potential to reduce these off-site losses by increasing thermal efficiency.

---

[5] Ibid.
[6] Ibid.
[7] 1998 Manufacturing Energy Consumption Survey (MECS), U.S. Department of Energy, Energy Information Administration, 2002.
[8] *Guide to the Business of Chemistry 2002,* American Chemistry Council.
[9] 1997 Census of Manufactures, U.S. Department of Commerce.
[10] *Guide to the Business of Chemistry 2002,* American Chemistry Council.

Exhibit 2
Energy Use in the Chemical Industry



THE CHALLENGE

Chemicals are integral to nearly every sector of the economy. The products of the chemical industry are essential raw materials for U.S. manufacturers, agriculture, construction, health care, communications, transportation, and national security. It is a complex industry, producing over 70,000 products using thousands of different processes. The industry relies heavily on a highly skilled workforce and continuous technological innovation to maintain competitiveness and economic growth.

Today, the chemical industry faces significant challenges in maintaining its leadership position in global markets. Competition from developing countries is putting increasing pressure on U.S. producers, particularly countries where energy and labor are cheaper, and government subsidies help to fuel new industry with less-stringent regulations. Growing societal demands for cleaner production and environmental stewardship continue to place increasing pressure on limited R&D funds. Demand for shorter-term returns on investment in recent years has also limited the amount of capital available for research activities, especially basic and applied research. The workforce of scientists and engineers engaged in chemical industry R&D has dropped in recent years by more than 10 percent, from 91,000 in 1999 to 81,000 in 2001.

The competitive demands facing chemical companies have led to a major change within this highly competitive industry. Companies are now willing to collaborate in strategic, pre-competitive areas to reduce costs, environmental impacts, and energy use. In *Technology Vision2020: The U.S. Chemical Industry*, the industry has emphasized that collaborative partnerships involving government, industry, and academia will be critical to meeting the technology challenges of the future and accelerating the pace of technological innovation. Recognizing that R&D consortia could benefit both industry and the nation, the industry has organized Chemical Industry Vision2020 Technology Partnership (Vision2020, see www.ChemicalVision2020.org), a group of executives from major U.S. chemical companies. This group works with government and academia to promote the development of more energy-efficient, environmentally sound chemical technology.

An Energy-Intensive Industry

Energy is a major factor in the technology equation for the chemical industry. The U.S. chemical industry is the second-largest consumer (petroleum is the largest) of energy in manufacturing, using more than 6.2 quads of delivered energy in 2001 and accounting for 16 percent of energy use. The magnitude of energy consumed by the industry makes it a prime target for energy efficiency R&D, with potentially large energy savings opportunities.

The industry relies primarily on petroleum and natural gas to provide feedstocks for the manufacture of chemicals. Nearly 50 percent of the energy consumed by the industry is for feedstocks – about 2.8 quads, or the equivalent of about 500 million barrels of oil. Transforming fossil energy and other raw materials into saleable products also consumes large amounts of energy in the form of heating, cooling, and electrical power.

While tremendous advances have been made in energy efficiency since the oil crises of the 1970s, the industry still relies on many processes which are inefficient and energy-intensive (e.g., distillation). When energy costs are low relative to the costs of processing and other inputs to production, investments in energy efficiency often take a back-seat to investments in environmental compliance or product development. However, increasingly stringent environmental regulations associated with the combustion of fuels and the growing volatility of energy markets is moving energy efficiency to the forefront. The record high prices for natural gas over the last 2 years, for example, have forced plants to close and to move new projects out of North America where natural gas is cheap and plentiful. The use of petroleum as a feedstock for commodity chemicals has served to increase our dependence on imported oil and impacts our energy security.

Both government and industry agree that conservation, or improving the efficiency of energy use, is part of

[11] M. S. Reisch, "Running Low on Gas," C&E News, July 14, 2003.

the solution for reducing energy consumption of both fuels and feedstocks in the chemical industry[11], especially in the long-term. Permanent technology changes, rather than short-term fixes, are needed to revolutionize the way energy is used in chemicals manufacture. New catalysts, for example, can dramatically increase product yield (the amount of product obtained from every barrel of oil) and reduce feedstock requirements. More efficient process heating technology can reduce the use of fuels and electricity. Alternatives to distillation could impact nearly 2 quads of energy use, annually.

Chemical industry R&D is a component of the overall EERE strategy to improve energy efficiency worldwide and contributes to the goals outlined in the National Energy Policy. Specifically, improving energy efficiency in chemicals manufacture could directly reduce the amount of petroleum imported into the United States and will reduce the energy intensity of industry, two of EERE's top priorities.

Strategy for Improving Chemical Industry Energy Efficiency

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) leads the federal role in developing advanced energy-efficient and environmentally friendly industrial technologies. The EERE Industrial Technologies Program implements the Chemical Industries of the Future (IOF) effort, which seeks to boost efficiency and productivity of the energy- and resource-intensive chemical industry.

The Chemical IOF responds to the unique challenges in the chemical industry by: 1) supporting collaborative, innovative R&D on chemical process technologies and design tools and methodologies; 2) promoting demonstrations of promising technologies; and 3) promoting the implementation of best practices and emerging technologies that will help the chemical industry achieve a 30 percent reduction in energy, water use, and toxic and pollutant dispersion per unit of output by 2020. The overall goal is to reduce energy use in the chemical industry by 233 trillion Btus per year in 2010 and 786 trillion Btus per year in 2020.

The Chemical IOF works in partnership with the Chemical Industry Vision2020 Technology Partnership (Vision2020, see www.ChemicalVision2020.org) to identify research priorities with broad applicability in the chemical industry on an ongoing basis. Vision2020 was formally established in 2001 to represent the needs of the entire chemical industry, bridging diverse interests and creating a unified voice. By partnering with Vision2020 and fostering collaboration with chemical industry trade organizations, the Chemical IOF leverages public and private resources and ensures the application of research results.

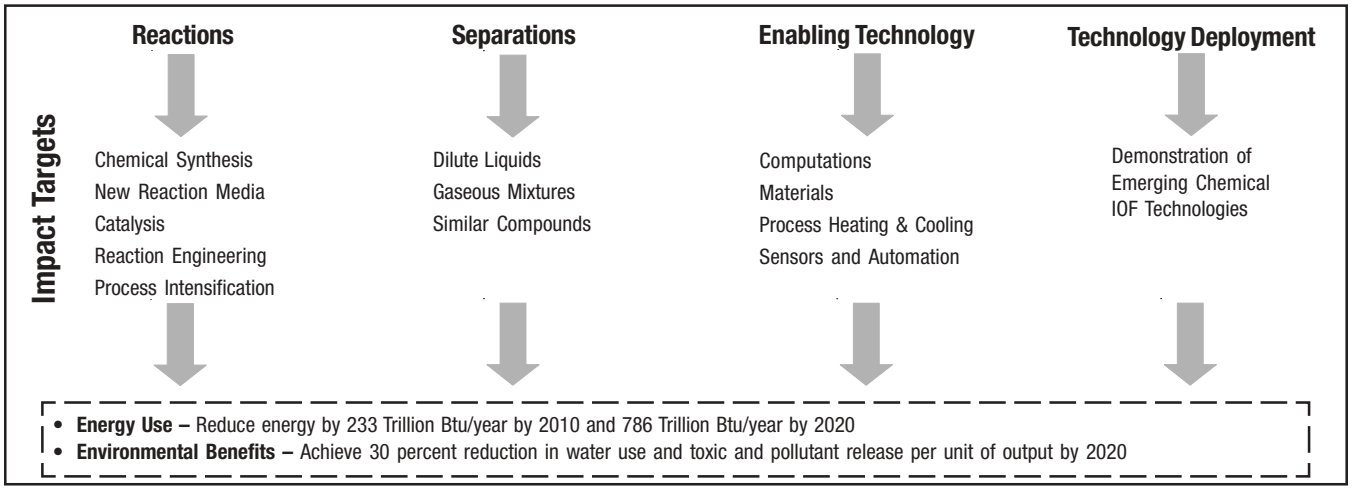
Vision2020 Executive Members

- Air Products and Chemicals Incorporated
- American Chemical Society
- American Institute of Chemical Engineers
- BP
- Ciba Specialty Chemicals
- Council for Chemical Research
- The Dow Chemical Company
- Eastman Chemical
- E.I. du Pont de Nemours and Company
- Honeywell International, Incorporated
- Materials Technology Institute of the Chemical Process Industries
- Praxair Incorporated
- Rohm and Haas Company

The Chemical IOF strategy fostered the development of Vision2020 and created the impetus for the industry to develop a long-term vision and numerous roadmaps for diverse research areas (See listing by topic area on pages 8-9). Chemical IOF solicitations reflect the priorities in the vision and roadmaps as well as ITP's analysis of opportunities for energy savings, national priorities, and the appropriate federal role. To assure broad participation among chemical companies, Chemical IOF solicitations are announced to the Chemical IOF Contacts database via email, in trade society publications, Web sites, meetings, the *Commerce Business Daily*, *FedBizOpps*, and the Chemical IOF Web site. Selection of projects follows merit-based criteria that emphasize projected energy, environmental, and economic benefits based on sound analysis using a standardized procedure available in the on-line Project Evaluation Tool (http://www.energetics.com/energysavingstool). This rigorous solicitation development and implementation process ensures targeted, competitive solicitations for pre-competitive R&D.

The Chemical IOF strategy is designed to have the greatest impact on reducing chemical industry energy intensity. The strategy evolves over time as R&D projects are funded and completed, as new opportunities to have a significant impact on the industry are identified, and as national priorities change. The Chemical IOF organizes its research portfolio into four categories: reactions, separations, enabling technologies, and technology deployment. Exhibit 3 shows the target areas of each of these research categories.

Exhibit 3
Process and Technology Improvements Target Energy Efficiency



The Chemical IOF portfolio was realigned in FY 2003 in response to an industry Portfolio Review in 2002. Furthermore, a large percentage of projects in the portfolio will end in FY 2004. In FY 2004, the chemical portfolio will transition to fewer, yet higher-risk, higher-impact research projects, that will have the opportunity to produce revolutionary improvements in chemical processing efficiency. The Chemical IOF program submits and manages technical topics for the DOE Small Business and Innovation Research and Small Business Technology Transfer (SBIR/STTR) Program Solicitation each year (see http://sbir.er.doe.gov/sbir). Recent topic areas include catalysis R&D for chemical manufacturing and refinery operations, bio-based products and bioenergy, membranes for advanced industrial separations, reactive separations, sensors, communication, and control technologies, and nanomaterials for industrial chemistry. The Chemical IOF also encourages other EERE programs to fund R&D priorities of the chemical processing industries.

The projects in the portfolio have significant risk to capital. The federal portion of funding seeks to reduce the risk. The portfolio includes high-risk, high-return R&D, applied research, applied development, demonstrations, and technology delivery projects. Most projects in the portfolio address R&D needs in multiple chemical industry segments and chemical chains. R&D is conducted by large and small chemical companies, national laboratories, and universities. Industry involvement accelerates the dissemination of research results and technology transfer.

Projects are distributed across the United States, with clustering at national laboratories and areas densely populated with chemical industry manufacturing facilities, such as Texas and the Northeast. The map on page 7 shows the distribution of projects throughout the country (principal investigators of core projects only).

Active Chemicals IOF Projects

The FY 2003 Industry Call solicitation focused on energy-intensive processes in chemical reactions and separations, which were needed to fill the gaps and balance the portfolio. It was released in January 2003 and eight new projects were announced in August 2003. The solicitation focused on reactions including chemical synthesis, new reaction media, catalysis, reaction engineering, and process intensification. The FY 2003 solicitation reduced the cost-share requirement, increased the funding available per project, and increased the period of research.

The FY 2004 Industry Call, released in August 2003, focused on high-risk, high-return applied research to address energy-intensive process areas that overlap the chemical, forest products, and petroleum refining industries. This solicitation reflected a major change in the Chemical IOF solicitation process. In this solicitation, applied research projects require a 30 percent minimum cost-share from non-federal sources. Applications for deployment of technology will be solicited in FY 2004.

FY 2003 HIGHLIGHTS & ACCOMPLISHMENTS

Fact sheets describing projects in the Chemical IOF portfolio are located on the Web at http://www.oit.doe.gov/chemicals.

The Chemical IOF supports a diverse portfolio of cost-shared, pre-competitive research that addresses high-risk technology with broad applications throughout the chemical industry. In FY 2003, the Chemical IOF core portfolio included 41 active projects and 23 emerging projects – five projects were completed (see Exhibit 4) and 17 projects were added to the portfolio in FY 2003. The core projects, organized by research categories, are listed in Exhibit 5. The portfolio includes 33 SBIR Phase II and STTR projects. In addition to the core portfolio, other EERE programs support projects that address key R&D priorities in the chemical processing industries (see Exhibit 6).

Exhibit 4 Chemical Projects with Completed Government Funding in FY 2003

1. Selective Oxidation of Aromatic Compounds (Reactions)
2. Multi-Phase Computational Fluid Dynamics (Enabling-Computations)
3. Alloy Selection System (Enabling-Materials)
4. Mixed Solvent Corrosion (Enabling-Materials)
5. Metal Dusting Phenomena (Enabling-Materials)

Exhibit 5 Core Chemical IOF Portfolio in FY 2003

Active Projects are projects that received funding in FY 2003. The Active Projects include:
***** Denotes project selected from the 2003 Industry of the Future Solicitation

Reactions

1. Production and Separation of Fermentation-Derived Acetic Acid, BP Amoco
2. Tackifier Dispersions to Make Pressure Sensitive Adhesives, West Virginia University
3. Microchannel Reactor System Design, Stevens Institute of Technology
4. Autothermal Reformer, Sandia National Laboratory
5. Short Contact Time Residence Reactors, Sandia National Labs
6. High Throughput Catalyst Screening, TDA Research
7. Ethylene Process Design Optimization, BP Amoco
8. Investigation of Advanced Chemical Conversion Approaches Based on Non-Thermal Plasma Facilitated Catalysis, Dupont Textiles & Interiors Inc.*
9. New Sustainable Chemistries for Low-VOC Coatings, Rohm & Haas Company*
10. Microchannel Reactor System for Catalytic Hydrogenation of Olefins by High-Intensity Oxidation, Stevens Institute of Technology.*
11. Advances in Process Intensification through Multifunctional Reactor Engineering, Chemical Research & Licensing Inc.*
12. Olefins by High-Intensity Oxidation, Velocys, Inc.*
13. Enhanced Chemical Processing using Dense Fluidized Beds, Millennium Chemicals*

Separations

14. Membranes for Corrosive Oxidations, Argonne National Labs
15. Mesoporous Membranes for Olefin Separation, Los Alamos National Labs
16. Separation of Olefin/Paraffin Mixtures with Carrier Facilitated Membranes, Membrane Technology & Research, Inc.*
17. Low-Cost Chemical Feedstocks using an Improved and Energy-Efficient Natural Gas Liquids Removal Process, Gas Technology Institute.*

Enabling Technology

Computations

18. Computational Chemistry and Reaction Engineering Workbench, Colorado School of Mines
19. Distillation Column Modeling Tools, Separations Research Institiute and Oak Ridge National Labs
20. Molecular Simulation for Chemical Industry, Sandia National Labs
21. Solution Crystallization Modeling Tools, OLI Systems

Materials

22. Corrosion Monitoring System (Enabling-Materials)
23. Chemical Industry Corrosion Management, Honeywell, Inc.
24. Alloys for Ethylene Production, Oak Ridge National Laboratory
25. Mixed Solvent, Corrosion, OLI Systems, Inc.
26. Metal Dusting Phenomenon, Argonne National Laboratory

Process Heating & Cooling

27. Enhanced Heat Exchangers for Process Heaters, Gas Technology Institute

Sensors

28. Accelerated Characterization of Polymer Properties, General Electric Co.
29. Distillation Column Flooding Predictor, 2nd Point Industries
30. Development of In-Situ Sensors for the Chemical Industry, Dow Chemical Co.

Technology Deployment

31. LPG Recovery with Ammonia Absorption Refrigeration, Giant Yorktown
32. Process Heater Ultra-Low Excess Air Control, Valero Energy
33. Membrane Process Field Demonstration for Olefin/Paraffin Separation, Novolen, Inc.
34. P-Xylene Production with Waste Heat Powered Ammonia Absorption Refrigeration, BP Chemical

Emerging Technologies are projects that will not receive additional funding in FY 2004 but are anticipated to be commercialized, some within the next three years. The Emerging Technologies include:

Reactions

1. Selective Oxidation of Aromatic Compounds
2. Short Contact Time Reactors
3. Autothermal Reformer
4. Novel Catalyst for CH_4-CO Conversion
5. Membrane Reactor Designs for the Production of Olefins
6. Sonic-Assisted Membrane Processing

Separations

7. Membrane for p-Xylene Separation
8. Mesoporous Membranes for Olefin Separation
9. Membranes for Corrosive Oxidation
10. Field Demonstration of a Membrane Process for Olefin/Paraffin Separation *(Technology Deployment)*
11. Waste-Powered AAR Unit for Recovery of LPG *(Technology Deployment)*
12. Economic and Self-Sustaining Production of Saleable Products from Waste Anions Using Phase-Transfer Catalysis
13. Novel Low-Cost Zeolite Ceramic Membrane Module

Enabling Technologies

14. Simulating Industrial Scale Flows
15. Multi-Phase Computational Fluid Dynamics
16. Alloys for Ethylene Production
17. Metal Dusting Phenomena
18. Mixed Solvent Corrosion
19. Computational Chemistry and Reaction Engineering Workbench
20. Instrumentation of Multi-phase Flows
21. Molecular Simulation for the Chemical Industry
22. Accelerated Characterization of Polymer Properties
23. Process Heater Ultra-low Excess Air Control *(Technology Deployment)*

Exhibit 6
Examples of Other EERE Projects Relevant to the Chemical Industry

(To learn more visit: www.eere.energy.gov)

Advanced Industrial Materials Projects Relevant to Chemicals

- Development of Ultrananocrystalline Diamond (UNCD) Coating for SiC Multipurpose Mechanical Pump Seals
- High Density Surface Treatments of Refractories
- Thermochemical Models and Databases for High Temperature Materials Processing and Corrosion
- Crosscutting Industrial Applications of a New Class of Ultra-Hard Borides
- Development and Demonstration of Advanced Tooling Alloys for Molds and Dies
- Advanced Composite Coatings
- Exploring Ultrahigh Magnetic Field Processing of Materials for Developing Customized Microstructures and Enhanced Performance
- Super Hard Materials
- Advanced Nanoporous Composite Materials for Industrial Heat Applications
- Advanced Chlor-Alkali Technology

Combustion Projects Relevant to Chemicals

- Integrated Process Heater System
- Development of an Innovative Energy Efficient High Temperature Natural Gas Fired Furnace
- Super Boiler: Packed Media/Transport Membrane Boiler Development and Demonstration
- Ultra-Low NOx Burners with FGR and Partial Reformer

Forest Products Projects Relevant to Chemicals

- Environmental Assessment of Low Temperature Plasma Technologies for Treating VOC's from Pulp Mills and Wood Products Plants
- Bubble Size Control to Improve Oxygen-Based Bleaching
- Stability and Regenerability of Catalysts for the Destruction of Tars from Biomass and Black Liquor
- Polyoxometalate Bleaching
- Volatile Organic Compound (VOC) Control in Kraft Mills
- Reducing VOC Press Emissions from Oriented Strand Board (OSB)
- Mill Bleaching Technologies
- Water Recycling/Removal Using Hydrogels
- High Selectivity Oxygen Delignification
- Non-Process Element Removal (NPE) Using Functionalized Monolayers on Mesoporous Supports
- Design and Demonstration of Multiport Cylinder Dryers (Continued Project)
- Development of METHANE de-NOx® Reburning Process for Wood Waste, Sludge, and Biomass-Fired Stoker Burners

Glass Program Projects Relevant to Chemicals

- Sensor Fusion for Intelligent Process Control

Inventions and Innovation Projects Relevant to Chemicals

- Compact and Efficient Chemical Reactor
- Energy-Saving Method for Producing Ethylene Glycol and Propylene Glycol
- Germanium Compounds as Highly Selective Fluorination Catalysts
- Low Frequency Sonic Mixing Technology

Mining Projects Relevant to Chemicals

- Selective Flocculation of Fine Mineral Particles led by DOE's Albany Research Center
- Novel Dewatering Aids for Mineral and Coal Fines led by Minerals and Coal Technologies, Inc.

NICE^3 Projects Relevant to Chemicals

- Plastic Manufacturing Through Recovered Post-Consumer Goods
- Supercritical Purification of Compounds Used for Combinatorial Chemical Analyses

Petroleum Projects Relevant to Chemicals

- Rotary Burner Demonstration
- Energy-Saving Separations Technology for the Petroleum Refining Industry
- Micro-Gas Chromatography Controller
- Biocatalytic Desulfurization of Petroleum

Sensors and Controls Projects Relevant to Chemicals

- Fiber-Optic Sensor for Industrial Process Measurement and Control
- Wireless Telemetry for Industrial Applications (All IOF Industries)
- Thermal Imaging Control of Furnaces and Combustors (Steel & Glass)
- Tunable Diode Lasers Sensors for Monitoring and Control of Harsh Combustion Environments
- Diagnostics and Control of Natural Gas-Fired Furnaces via Flame Image Analysis Using Machine Vision and Artificial Intelligence Techniques

EERE/Fossil Energy Science Initiative

- Atomic-scale Design of Cobalt Fischer-Tropsch Catalysts: A Combined Computational Chemistry Experiment and Microkinetics Modeling Approach
- Design Synthesis and Mechanistic Evaluation of Iron-Based Catalysis for Synthesis Gas Conversion to Fuels and Chemicals
- Separation of Fischer-Tropsch Wax Products from Ultra-fine Iron Catalysts
- A Novel Polymer-derived Nano-Ceramic for Ultrahigh Temperature MEMS

In addition to sponsoring R&D, the Chemical IOF achieved a number of noteworthy accomplishments in FY 2003. These accomplishments are described below:

R&D Highlights

Catalytic Hydrogen Retrofit Reactor (Monlith Loop Reactor) – Johnson Matthey and Air Products & Chemicals investigated the retrofitting of catalyst systems into existing stirred-tank reactor systems. The procedure leads to increased reactor rates and avoids the use of slurry catalysts. In November 2002, the project partners announced a marketing agreement to commercialize the technology. Widespread implementation of this technology offers the potential for 0.2 trillion Btu savings per year by 2020, the year of complete market penetration. DOE cost-share was completed in 2002.

Membranes for Olefin Recovery – Membrane Technology Research Inc., Phillips Surnika, and Equistar developed a membrane separation process to recover olefins in gaseous olefin/paraffin waste streams for use as in-process feedstock. Scale-up models have been developed and tested at Phillips Surnika and secondary tests are taking place at an Equistar polypropylene plant. Commercialization of this technology could reduce energy use by 0.8 trillion Btu by 2020 and recover over 0.42 billion pounds of olefins per year. This project continued a 2001 SBIR award.

Pressure Swing Adsorption for Product Recovery – Air Products & Chemicals and the University of Kentucky developed an energy-efficient process employing pressure swing adsorption refrigeration (PSA) for the recovery of olefins from polyolefin plant vent gases. There are already two commercial applications of the PSA technology. Widespread commercialization could yield a recovery rate of over 17 million pounds of olefins per year, as well as energy and emission reductions. Project cost-share from DOE was completed in 2002.

Alloys for Ethylene Production – BP Chemicals, Exxon Chemical Company, Shell Chemical Company, Air Products & Chemicals, Oak Ridge National Laboratory, and six other industry partners are developing metallic and intermetallic materials that allow for the production of ethylene furnace tubes resistant to coking and carburization. This innovative technology has the potential to prevent carburization coke formation in tubes, allow for longer tube service life, reduce downtime, and improve reaction conditions. Project cost-share from DOE is expected to be completed in 2003.

Multi-phase Fluid Dynamics Research Consortium – This consortium was established to support learning and fundamental research to better understand and model multi-phase flows. Its members include Chevron, Texaco, Dow Chemical, Dow Corning, DuPont, ExxonMobil, Millennium Chemicals, Fluent, AEA Technology, seven universities, and six national laboratories. The team has already developed improved computational fluid dynamics software, two insightful modeling techniques, and it continues to educate a scientific community.

Partnership Highlights

Utility Mapping and Benchmarking Tool, conceived in FY 2002 and developed in FY 2003, will enable plant engineers to create a benchmark energy map that defines how much and where energy is used in individual facilities. The initial emphasis is on the chemical and petrochemical industries, and development is being undertaken as a collaborative effort involving DOE, AIChE, and Veritech. The tool uses energy data developed through the chemical "energy footprint" as a starting point, and then allows users to input actual utility data and nameplate capacity to create a plant-specific energy map. Utility data includes metered electricity and natural gas or coal and other fuels delivered to the plant. The tool also incorporates input on energy generation (steam, heat, self-generated electricity) and export of energy from the plant. Using embedded and user-entered data, the tool allocates energy to major uses in the plant such as process heating, steam, pumps, compressors, and so forth. A scorecard is ultimately created for each utility area and estimates energy losses as well as potential opportunities for energy and cost savings. Users are then directed to a possible suite of other tools or technologies that could be used to achieve energy savings (e.g., PSAT). In the future, scorecards could be submitted confidentially to a third-party like ACC to create an industry-wide benchmark. Dupont, Millennium, BASF, Dow, Rohm and Haas, and Reilly Industrial will beta test the software.

The Chemical Industry R&D Roadmap for Nanomaterials by Design: From Fundamentals to Function is expected to be published by Vision2020 in November 2003. The roadmap was written for the chemical industry by a Vision2020 team and was sponsored by ITP and the federal agencies participating in the National Nanotechnology Initiative.

Ionic Liquids Roadmapping Workshop, held in September 2003 in conjunction with the American Chemical Society's annual meeting, was sponsored by ITP and Vision2020. The report will be completed in January 2004.

Vision2020 published an 8-page *Annual Report 2002* announcing success in stimulating about $92 million in public and private R&D investments in 2002. The *Annual Report* is available at www.ChemicalVision2020.org.

Three Allied Partners in the chemical industry made a significant contribution in FY 2003:

- **Millennium Chemicals Inc.** helped with the development of the utility benchmarking tool, attended the Steam Steering Comitteee meeting hosted by DOE-EERE, and completed the Allied Partner agreement. The Motor Master+ and 3E+ programs were demonstrated at Millennium's headquarters by LBNL and they also sponsored a 3-day training program with the Maryland State IOF program covering motors, compressed air, and steam systems.

- **Rohm & Haas** helped with the development of the utility benchmarking tool, participated in the Texas Showcase, and hosted a PSAT end-user training workshop sponsored by the Texas IOF program. Rohm & Haas also sponsored the boiler and steam systems, CAC fundamentals, and PHAST workshops.

- **AIChE** submitted, with LBNL, a pumping system paper for publication, hosted discussion and helped develop the utility benchmarking tool, and participated in the Texas Technology Showcase. AIChE co-sponsored both a PSAT and a boiler and steam end-user training workshop.

Improving Energy Efficiency Today

Plant-wide Assessments (PWAs) are cost-shared assessments of plant utility and process-related energy efficiency opportunities across a plant. Plants are eligible through a competitive solicitation. In FY 2003, the Formosa Plastic PWA was completed and a showcase PWA at Rohm & Haas is underway. Based on the experience of other manufacturers, these companies can expect to cut energy costs by anywhere from $1 million to $10 million per year. Success stories from PWAs are available on the Web site at http://www.oit.doe.gov/bestpractices/case_studies_pwa.shtml.

Disseminating Research Results to Industry

The Chemical IOF conducts numerous outreach activities to disseminate R&D results and encourages companies to reduce energy intensity of chemical processing. The highlight in FY 2003 was the Texas Technology Showcase described below. In addition, the Chemical IOF participated in trade shows and annual meetings, and maintained an up-to-date Web site that highlights activities.

Texas Technology Showcase, held March 17-19 in Houston, Texas, was hosted by EERE/ITP Chemicals and Petroleum programs and the Texas Industries of the Future. The Showcase attracted over 400 individuals from the chemical and refining industries and highlighted technologies and best practices for improving energy efficiency, advancing environmental performance, and reducing costs in chemical and refining processes. A **2-CD set** is available that contains information about the event, technical materials and video clips from the presentations, case studies, and tour books for the Showcase plants and companies. Information can also be found at http://www.oit.doe.gov/showcasetexas. The following companies participated in the showcase:

- Calpine Corporation, Baytown Energy Center
- Chevron Phillips Chemical Company LP, Cedar Bayou Plant
- Deer Park Plant
- The Dow Chemical Company
- Merisol USA, LLC
- Rohm and Haas Texas, Inc.
- Valero Energy Corporation, Houston Refinery
- ExxonMobil Corporation

Energy Analysis – Targeting Energy Efficiency

The **Energy Bandwidth Study** was launched in FY 2003 to show the magnitude of energy savings possible for 20 commodity chemicals. The energy "bandwidth" will be used to provide a rationale for supporting R&D on new technologies with the highest potential impact on chemical industry energy consumption.

The **Energy Footprint Study** of the Chemical Industry, showing the flow of energy throughout the industry, was completed in FY 2003. The energy flow and losses are shown for energy supply, central energy generation/utilities, energy distribution, energy conversion, and process energy.

The **Project Evaluation Tool** was updated to include 50 chemicals for standardized analysis of energy, environmental, and economic benefits of the chemical projects in the portfolio. Applicants to the Chemical IOF solicitations are now required to use the updated project evaluation tool.

The **GPRA Analysis** was completed for projects considered in the FY 2005 budget. The GPRA analysis estimates future benefits of emerging technologies in the chemical portfolio based on market penetrations, energy savings, and environmental emission reductions.

The **Economic Evaluation Tool** is under development and will be used to analyze a technology's potential market penetration and to estimate project benefits. This tool will be used with the project evaluation tool to enhance DOE's project funding criteria to increase the overall energy and environmental benefits of the chemical portfolio.

Climate VISION

On February 14, 2002, President Bush announced a new strategy to address the long-term challenge of global climate change. The President committed to reducing America's greenhouse gas intensity – the ratio of emissions to economic output – by 18 percent in the next decade, and challenged American businesses and industries to undertake broader efforts to help meet the goal. The President's strategy, known as Climate VISION (Voluntary Innovative Sector Initiative: Opportunities Now), is focused on voluntary partnerships between the government and entire industry sectors. These partnerships aim to reduce the projected growth in America's greenhouse gas emissions through research, development, and deployment of energy-saving technologies and processes.

The U.S. Department of Energy, along with other key Federal Agencies, recognizes that major, energy-intensive sectors of the American economy are undertaking significant initiatives to meet the President's challenge. These initiatives build upon the progress made by the industrial sector in the past decade: from 1990-2001. During this time, the economy grew by almost 40 percent, while greenhouse gas emissions in the industrial sector remained constant. The Industrial Technologies Program (ITP) is working in partnership with U.S. chemical industry through the American Chemistry Council to implement activities in support of ACC achieving its Climate VISION commitment. A Climate VISION workplan is being developed where ACC will be collaborating with the Federal government on near-term energy efficiency activities, cross-sector projects, and R&D to develop and commercialize advanced technology (see Climate VISION Web site www.climatevision.gov/).

TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

EERE offers valuable tools and publications to help chemical companies improve productivity and energy efficiency. Some of these resources are described below. See the Web site at http://www.oit.doe.gov/chemicals for a complete listing.

Technology Vision2020: The U.S. Chemical Industry – This landmark document, developed with participation from over 300 companies and released in 1996, outlines a unified vision for the chemical industry in 2020, and identifies industry-wide goals for making more efficient use of energy and raw materials, better managing of the supply chain, and enhancing environmental performance.

R&D Roadmaps – Groups of chemical companies have come together to jointly develop R&D agendas or "roadmaps" that outline priority R&D needs in critical technology areas. To date, the industry has completed the roadmaps listed below. See the Web site at http://www.oit.doe.gov/chemicals/visions.shtml to download a copy.

- Biocatalysis
- Combinatorial Chemistry
- Computation Chemistry
- Computational Fluid Dynamics
- Materials of Construction
- Materials Technology
- New Process Chemistry
- Reaction Engineering
- Separations

Fact Sheets and Success Stories – Publications describing research, development, and demonstration (RD&D) projects are available.

Resources and Tools for Energy Efficiency and Cost Reduction Now CD – The CD provides tips and tools for spotting the biggest energy–saving opportunities in chemical plants today as well as details on energy efficiency technologies.

Beyond the Molecular Frontier – This National Research Council report examines the current state of knowledge across the chemical sciences and outlines the challenges for the 21st century.

Highlights of Biopower Technical Assessment – This report assesses the current status of the biopower industry for producing electricity and heat from biomass.

A Pilot Study of Energy Efficiency Performance Levels for the U.S. Chemical Industry: A Methodology for Determining Practical Minimum Energy Metrics – This study discusses preliminary results of a joint study with AIChE to develop and implement tools and methodologies to estimate energy performance levels.

Energy and Environmental Profile of the Chemical Industry – A detailed report benchmarking the energy and environmental characteristics of key technologies used in major processes of the chemical industry.

Project Evaluation Tool – Software is available on the Chemical IOF Web site that can be used to estimate the potential energy and environmental benefits of a proposed new chemical technology (see http://www.oit.doe.gov/chemicals).

HOW TO GET INVOLVED AND CONTACT INFORMATION

Partnership Information

Public-private partnerships are the foundation of ITP's technology delivery strategy. ITP includes its partners in every phase of the technology development process to focus scarce resources where they can have the greatest impact on industrial energy efficiency. To learn more, please visit our Web site at www.eere.energy.gov/industry.

- Collaborative, **cost-shared research and development** projects are a central part of ITP's strategy. Annual solicitations provide technology development opportunities in a variety of energy-intensive industries.

- **Industries of the Future Partnerships** increase energy efficiency in the most energy-intensive industries. In addition to cost-shared research and development projects, industry partners participate in the development of vision and roadmap documents that define long-term goals, technology challenges, and research priorities.

- **Allied Partnerships** provide an opportunity for ITP to reach a broad audience of potential customers by allying with corporations, trade associations, equipment manufacturers, utilities, and other stakeholders to distribute industrial energy efficiency products and services. By becoming an Allied Partner, an organization can increase its value to clients by helping them achieve plant efficiencies.

- **State energy organizations** work with ITP in applying technology to assist their local industries. ITP assists states in developing IOF partnerships to mobilize local industries and other stakeholders to improve energy efficiency through best practices, energy assessments, and collaborative research and development.

- **EERE's technical programs** (of which ITP is one of eleven) give manufacturers access to a diverse portfolio of energy efficiency and renewable energy technologies and bring advanced manufacturing technology to the renewable energy community. For more information, access the EERE home page at www.eere.energy.gov.

- The President's **Climate VISION** (Voluntary Innovative Sector Initiatives: Opportunities Now) effort also offers opportunities for manufacturers to pursue cost-effective actions that will reduce greenhouse gas emissions. See www.climatevision.gov for details.

Access to Resources and Expertise

The Industrial Technologies Program provides manufacturers with a wide variety of industrial energy efficiency resources to help your company cut energy use right away. Visit our site at www.eere.energy.gov/industry or call the EERE Information Center at 877-337-3463 to access these resources and for more information.

- ITP offers **energy management best practices** to improve energy efficiency throughout plant operations. Improvements to industrial systems such as compressed air, motors, process heat, and steam can yield enormous savings with little or no capital investment.

- Our suite of powerful system optimization **software tools** can help plants identify and analyze energy-saving opportunities in a variety of systems.

- **Training sessions** are held several times per year at sites across the country for companies interested in implementing energy-saving projects in their facilities. DOE software tools are used as part of the training sessions.

- ITP's qualified **industrial energy specialists** will work with your plant personnel to identify savings opportunities and train staff in the use of ITP software tools.

- Our extensive library of **publications** gives companies the resources they need to achieve immediate energy savings.

- **Plant-wide energy assessments** are available to manufacturers of all sizes interested in cutting their energy use. Cost-shared solicitations are available each year for plant-wide energy assessments. In addition, no-cost, targeted assessments are provided to eligible facilities by teams of engineering faculty and students from 26 university-based Industrial Assessment Centers around the country.

- The **DOE Regional Offices** provide a nation-wide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in Atlanta, Boston, Chicago, Denver, Philadelphia, and Seattle. Visit www.eere.energy.gov/rso.html for more information.

Where to Go to Get More Information

Visit our Web site - www.oit.doe.gov/chemicals

Learn about all EERE Programs - www.eere.energy.gov

Ask an Expert - The Office of Industrial Technologies Clearinghouse is a great way to access ITP's resources. Times available are 9 a.m. to 8 p.m. EST (6 a.m. to 5 p.m. PST).
Phone: 1-800-862-2086
Fax: 360-956-2214
Email: clearinghouse@ee.doe.gov
For print copies of DOE, EERE, and ITP Publications, contact:
Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
Fax: 703-893-0400
Phone: 800-363-3732
Email: doe.erec@nciinc.com

For questions regarding Chemical IOF activities, please contact -
Dickson Ozokwelu
Industrial Technologies Program
Office of Energy Efficiency and Renewable Energy
EE-2F
U.S. Department of Energy
1000 Independence Ave SW
Washington, DC 20585-0121
Phone: 202-586-8501
Fax: 202-586-9234
Email: Dickson.Ozokwelu@ee.doe.gov

Brian Valentine
Industrial Technologies Program
Office of Energy Efficiency and Renewable Energy
EE-2F
U.S. Department of Energy
1000 Independence Ave SW
Washington, DC 20585-0121
Phone: 202-586-1739
Fax: 202-586-9234
Email: Brian.Valentine@ee.doe.gov

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and great energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as a vital new "energy carrier"

The Opportunities

Biomass Program
Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program
Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program
A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program
Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program
Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program
Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program
Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program
Utilizing the sun's natural energy to generate electricity and provide water and space heating

Weatherization & Intergovernmental Program
Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and business

Wind & Hydropower Technologies Program
Harnessing America's abundant natural resources for clean power generation

To learn more, visit www.eere.energy.gov

Chemical Industry of the Future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry

U.S. Department of Energy
Energy Efficiency and Renewable Energy

published January 2004